Preoperative assessment of vessel-to-acetabular rim distances in non-contrast CT images for total hip arthroplasty

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Abstract: Vessel injuries during total hip arthroplasty (THA) pose life-threatening risks. This study aims to develop a preoperative approach for assessing vessel-to-acetabular rim distances for surgical planning. The proposed solution consisted of two main steps: 1) automatic segmentation of the pelvic bone (including the acetabular rim), vessels (external iliac artery and vein), and nerves from non-contrast CT images, and 2) distance assessment within high-risk locations. The reason for selecting non-contrast CT images was their wide adoption in THA surgical planning. The approach was validated on a database comprising 36 non-contrast CT images of hip osteoarthritis (OA) patients and 18 pairs of contrast-enhanced/non-contrast CT images of non-hip OA patients. For the hip OA database, ground truth (GT) labels of the segmentations were manually annotated. For the non-hip OA database, arterial GT labels were constructed using registered contrast-enhanced CT images. Segmentation accuracy was evaluated using the Dice coefficient (DC) and average symmetric surface distance (ASD). The accuracy of distance assessment was evaluated using the mean absolute error (MAE) and Pearson correlation coefficient (PCC). The DC for hip OA patients was 0.816, 0.852, and 0.988 for the artery, vein, and pelvis, respectively, and 0.864, 0.884, and 0.996 for non-hip OA patients. The PCCs between the GT and auto-segmentation-based distances were larger than 0.97, with a mean MAE smaller than 0.5 mm in high-risk locations. In conclusion, the study presents a preoperative approach for assessing vessel-to-rim distances in non-contrast CT images, demonstrating high accuracy in automated vessel segmentation and distance assessment. The proposed approach shows the feasibility of risk assessment of vessel injury in THA surgical planning based on non-contrast CT images.

Keywords: total hip arthroplasty, image segmentation, non-contrast CT, vascular injury, risk assessment, surgical planning